

# *Modeling Coastal Evolution in Southern California: Geomorphic Response to Sea Level Rise and Changes in Wave Climate*

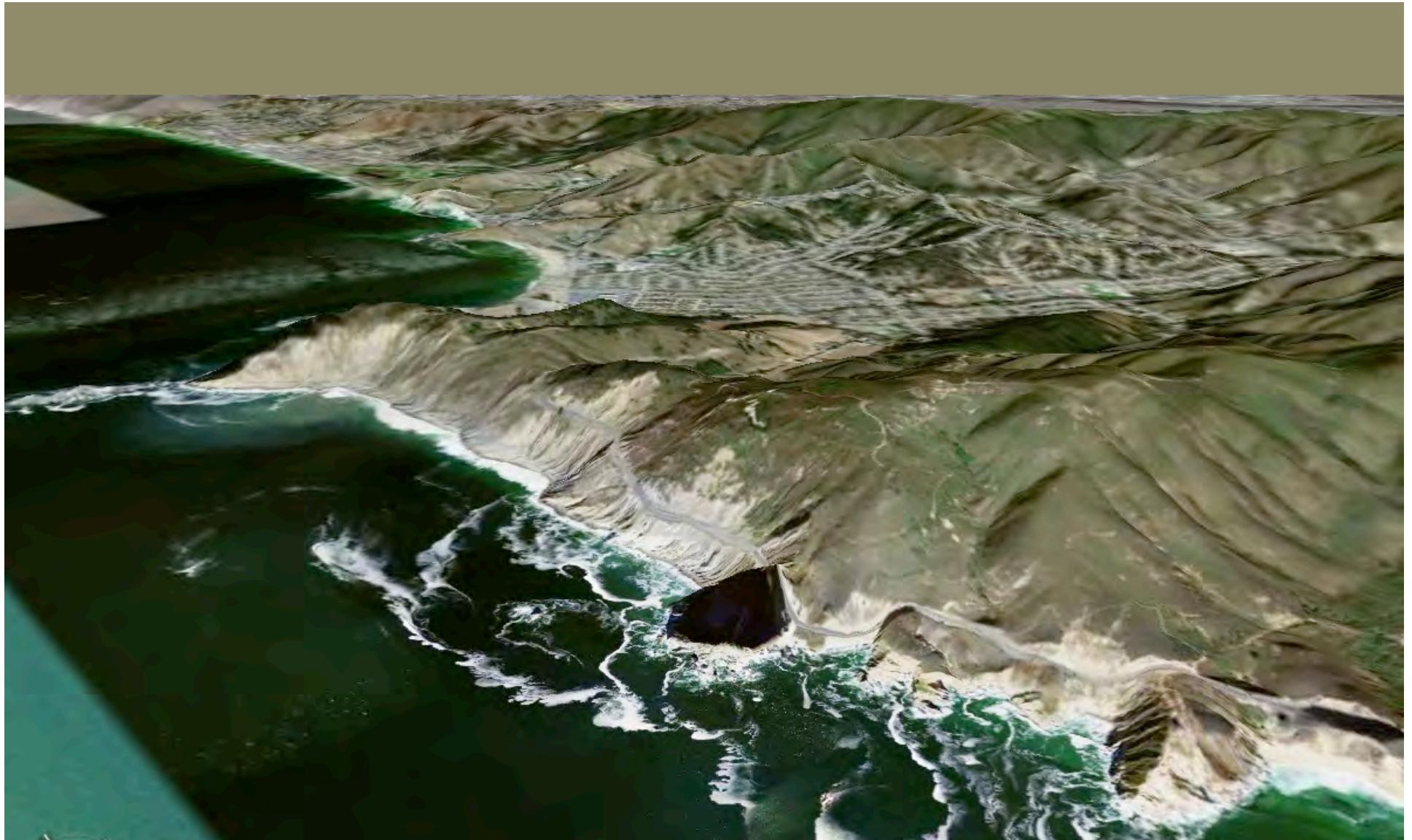
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Nick Graham  
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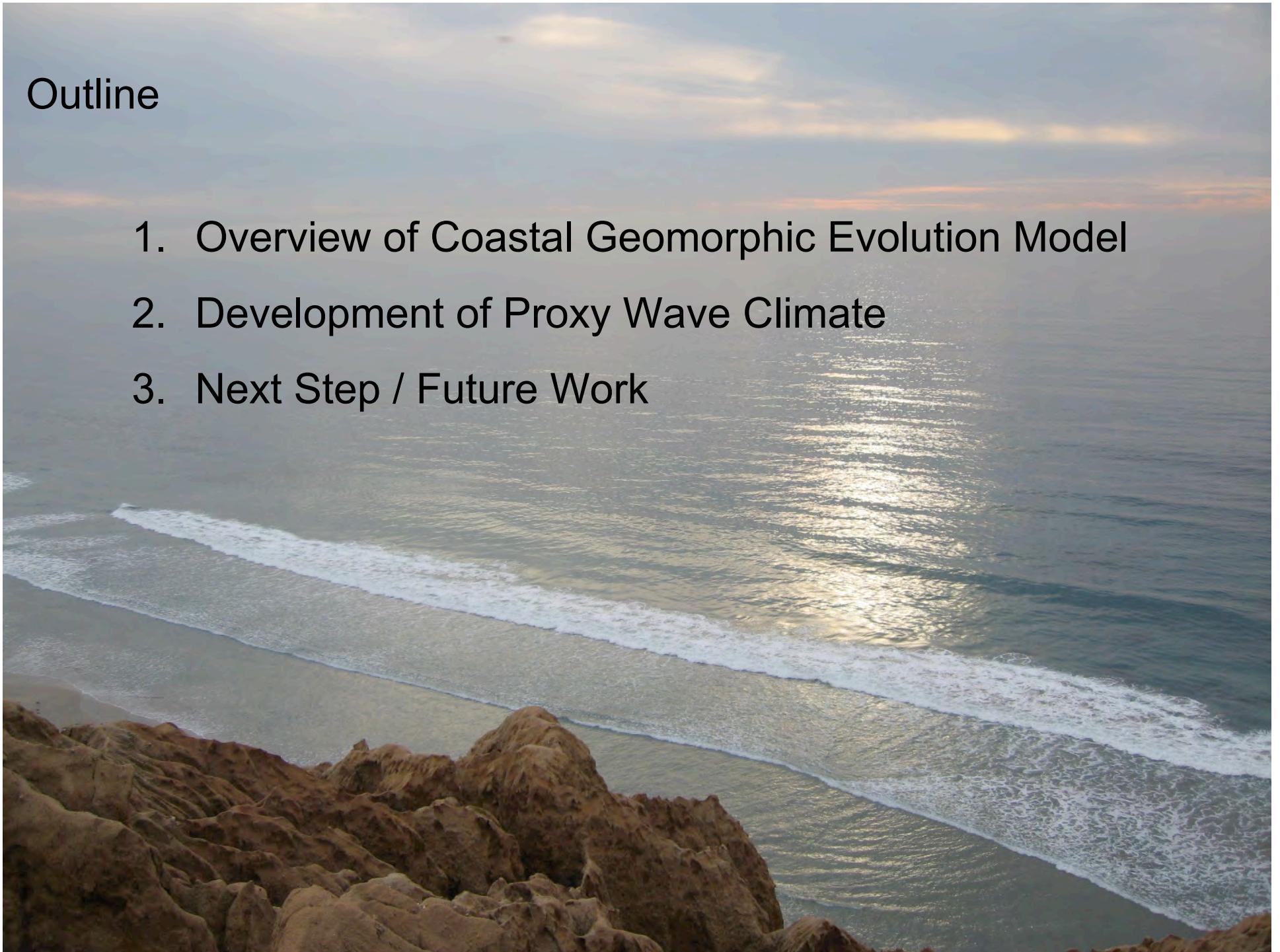
Scripps Beach, La Jolla - March 2006



Central Coast - San Mateo County

# Outline

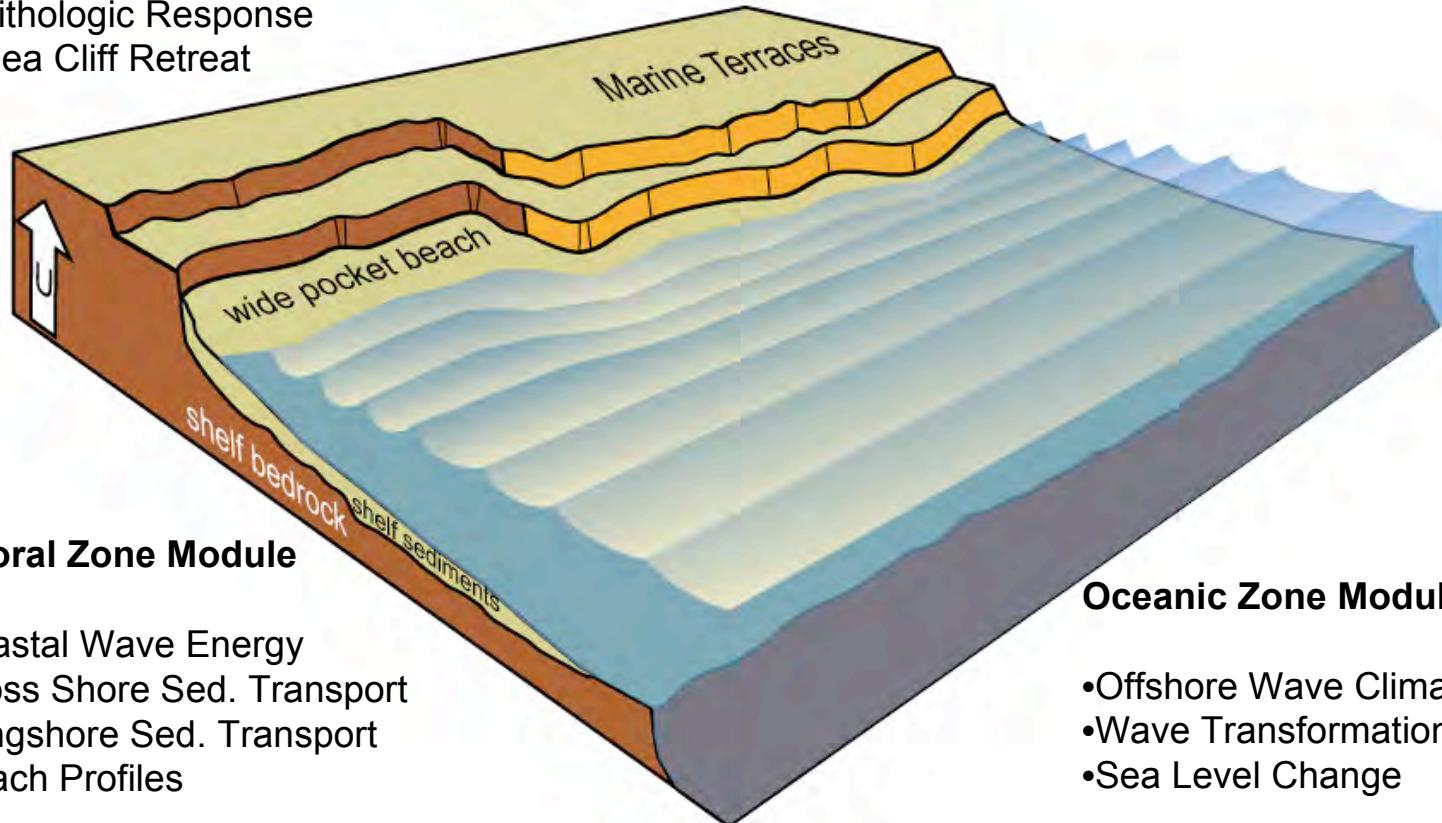
1. Overview of Coastal Geomorphic Evolution Model
2. Development of Proxy Wave Climate
3. Next Step / Future Work



# Modules of Coastal-Geomorphic Evolution Model (C-GEM)

## Terrestrial Zone Module

- Regional Geology
- Lithologic Response
- Sea Cliff Retreat



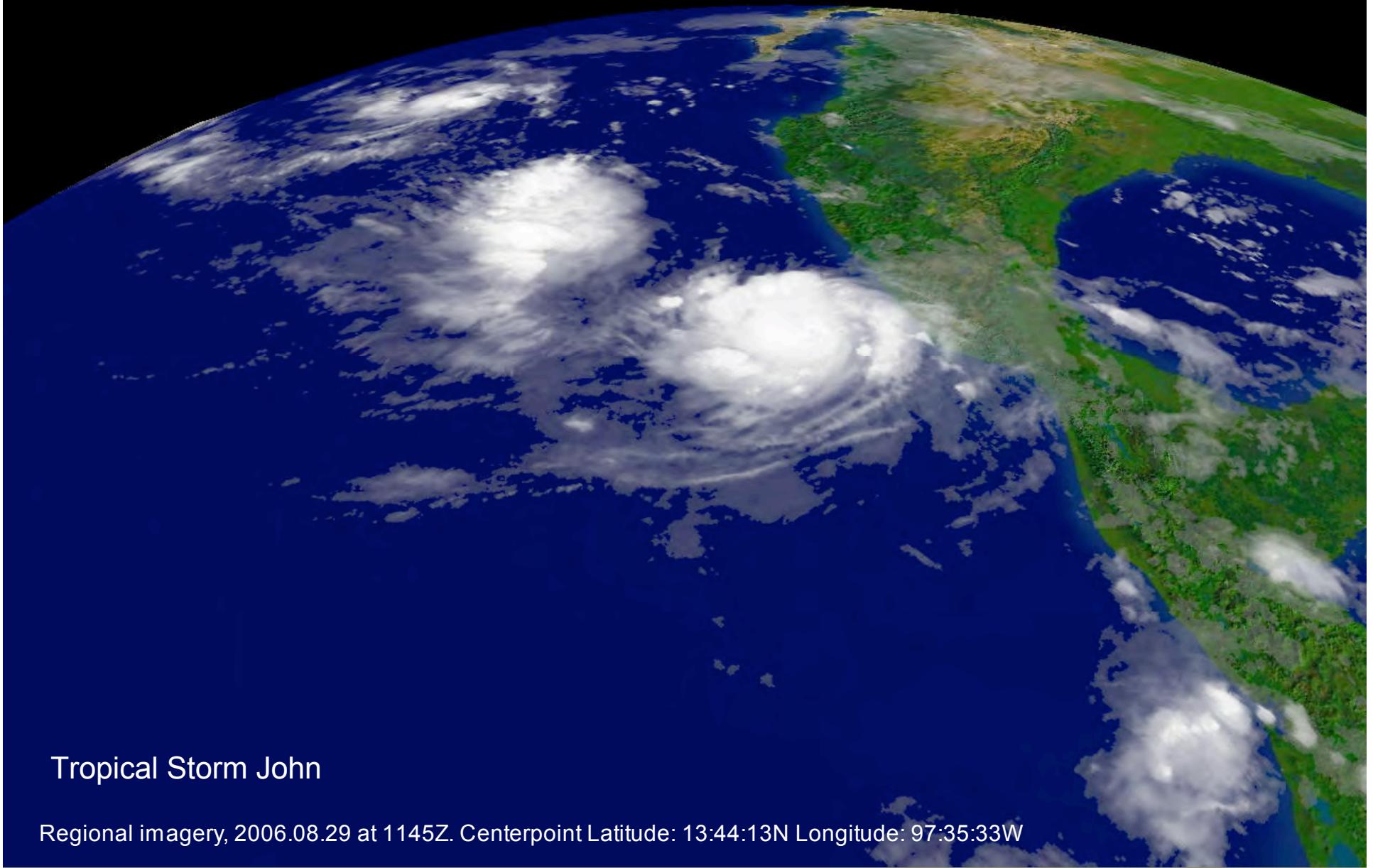
## Littoral Zone Module

- Coastal Wave Energy
- Cross Shore Sed. Transport
- Longshore Sed. Transport
- Beach Profiles

## Oceanic Zone Module

- Offshore Wave Climate
- Wave Transformation
- Sea Level Change

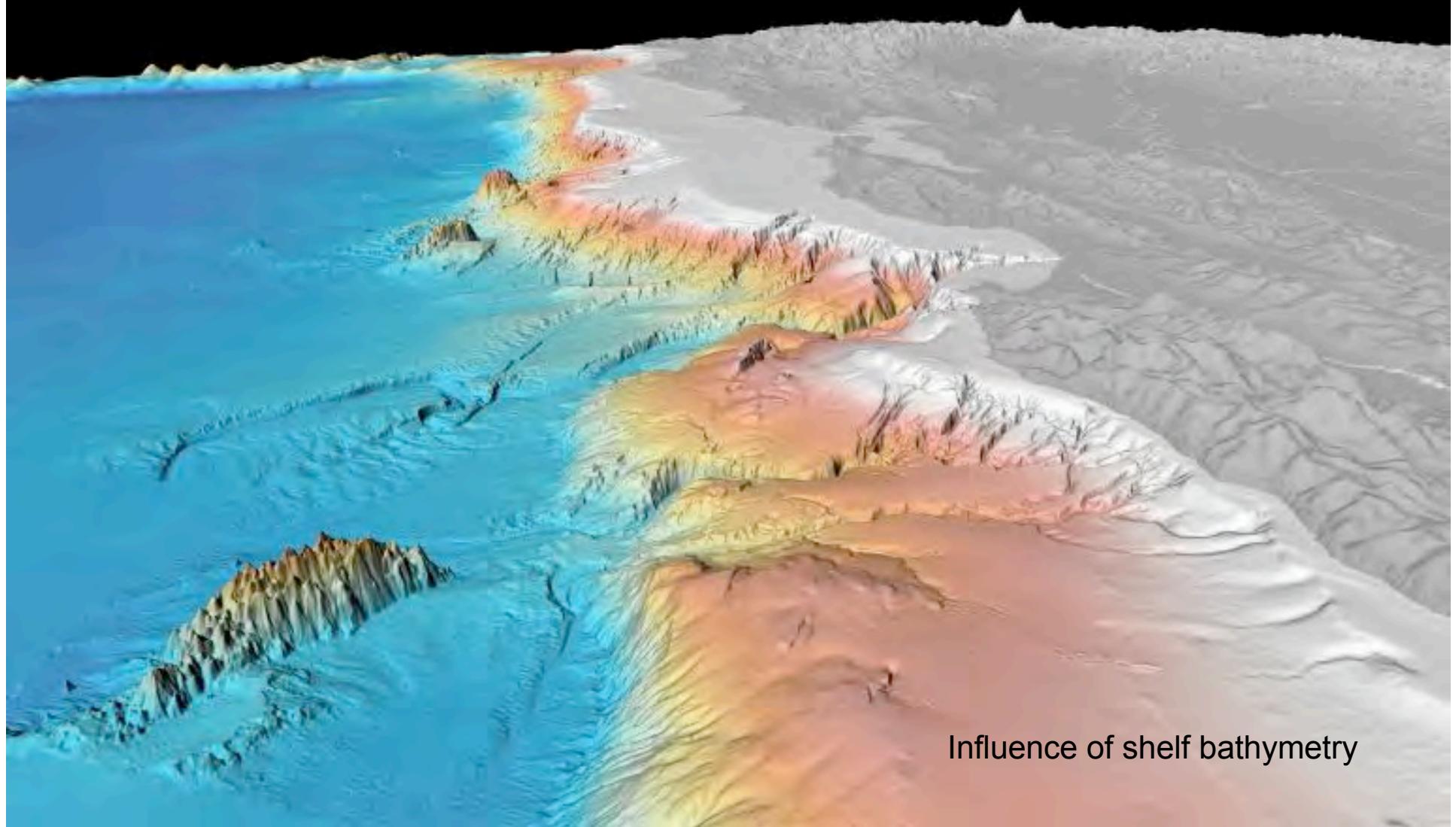
# Oceanic Zone Module



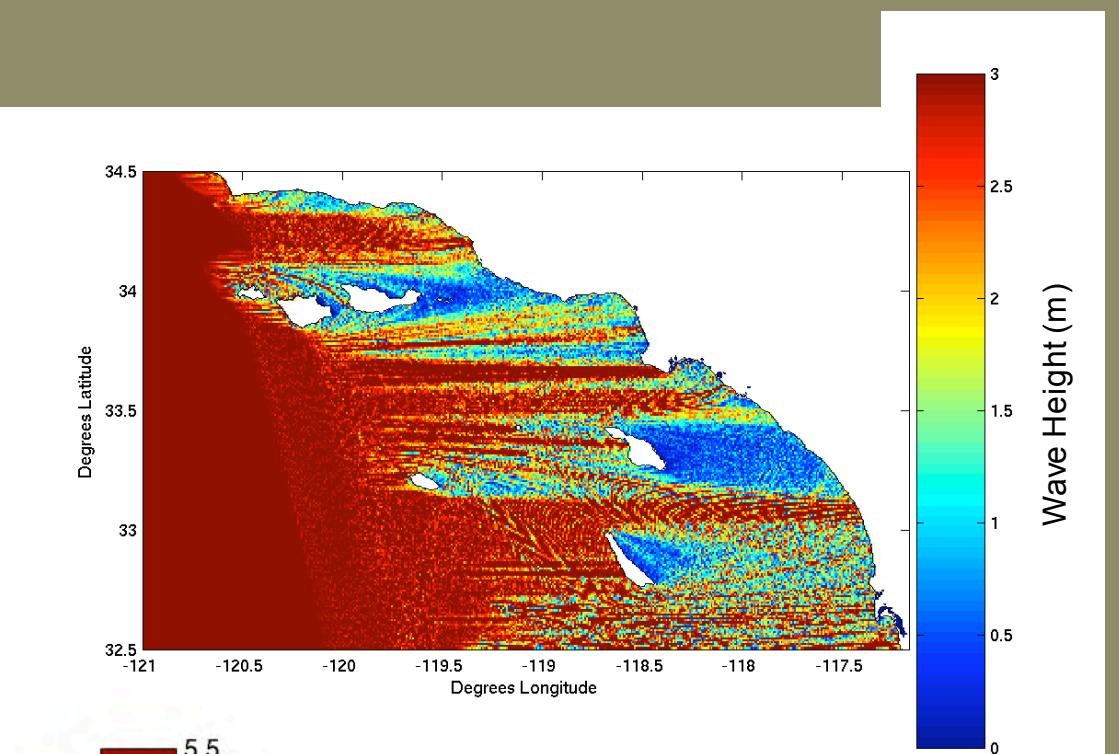
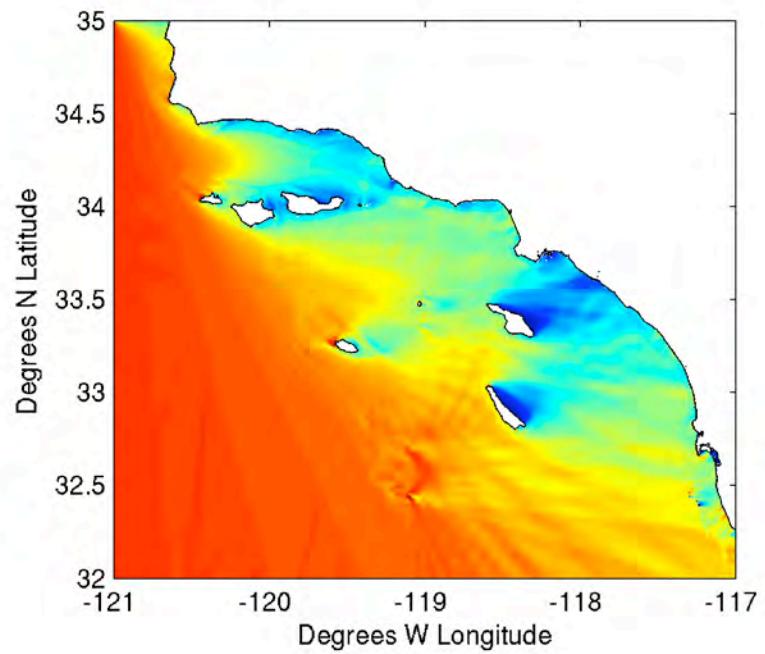
Tropical Storm John

Regional imagery, 2006.08.29 at 1145Z. Centerpoint Latitude: 13:44:13N Longitude: 97:35:33W

# Oceanic Zone Module



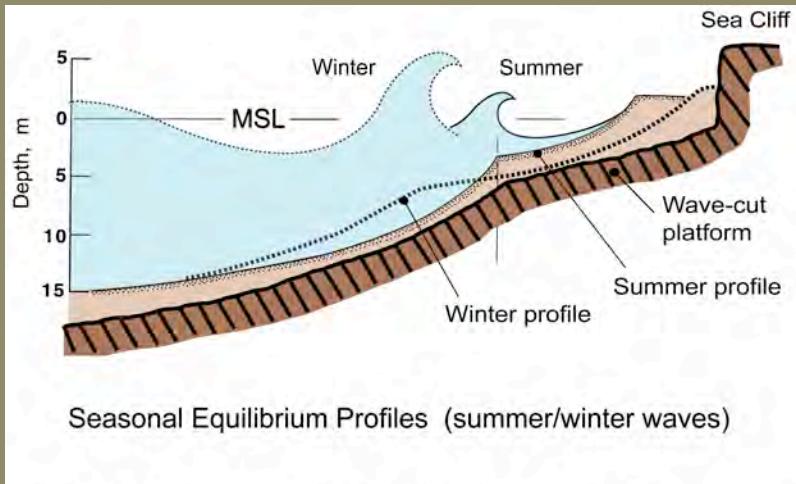
# Oceanic Zone Module



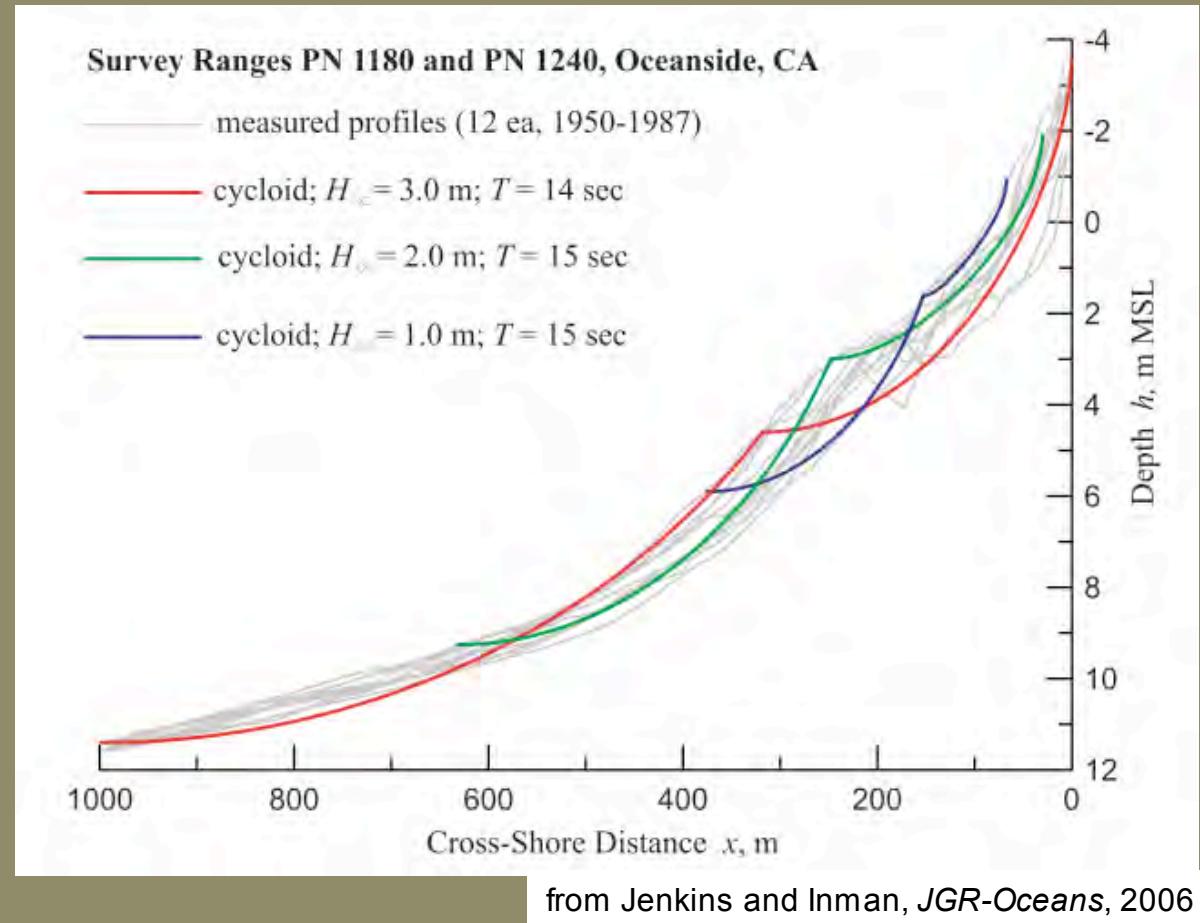
REFDIF - monochromatic model

SWAN - spectral model

# Littoral Zone Module



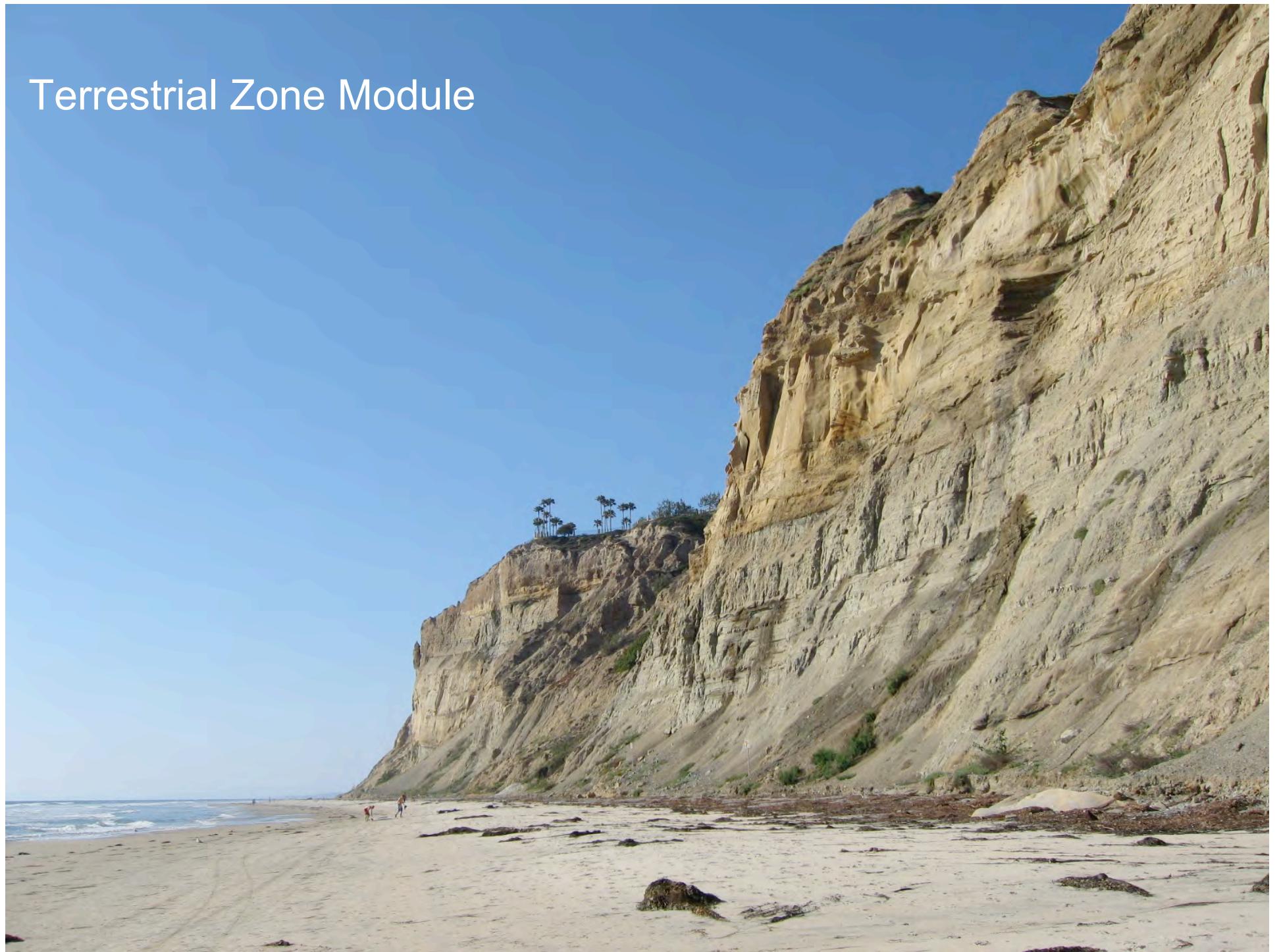
# Littoral Zone Module



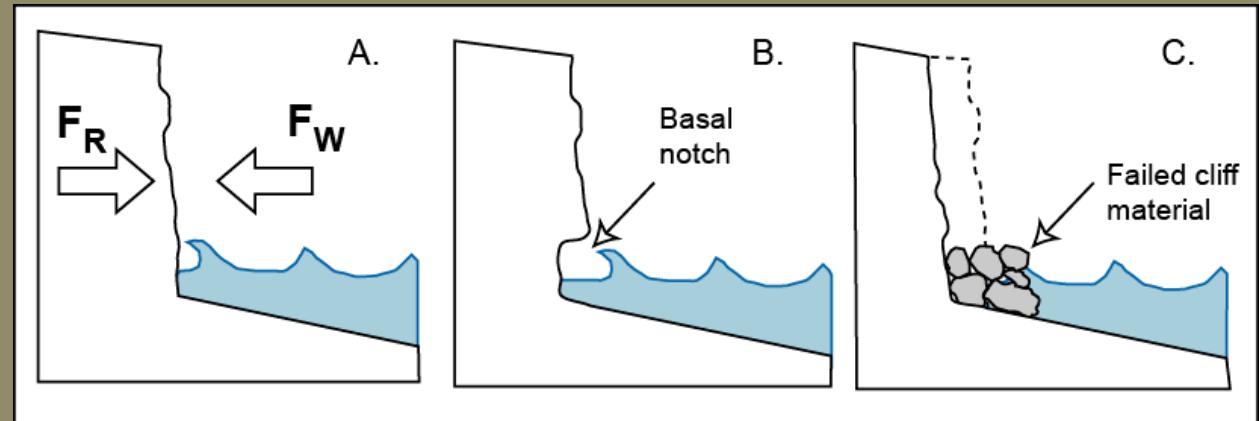
Must determine closure depth / envelope of beach profiles

Thermodynamic solutions model by Jenkins and Inman (2006)

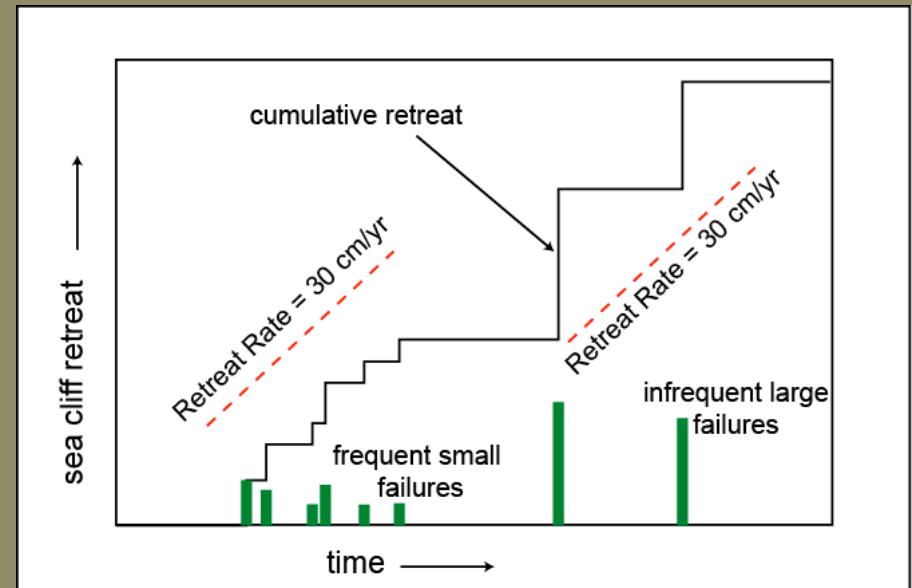
# Terrestrial Zone Module



# Terrestrial Zone Module



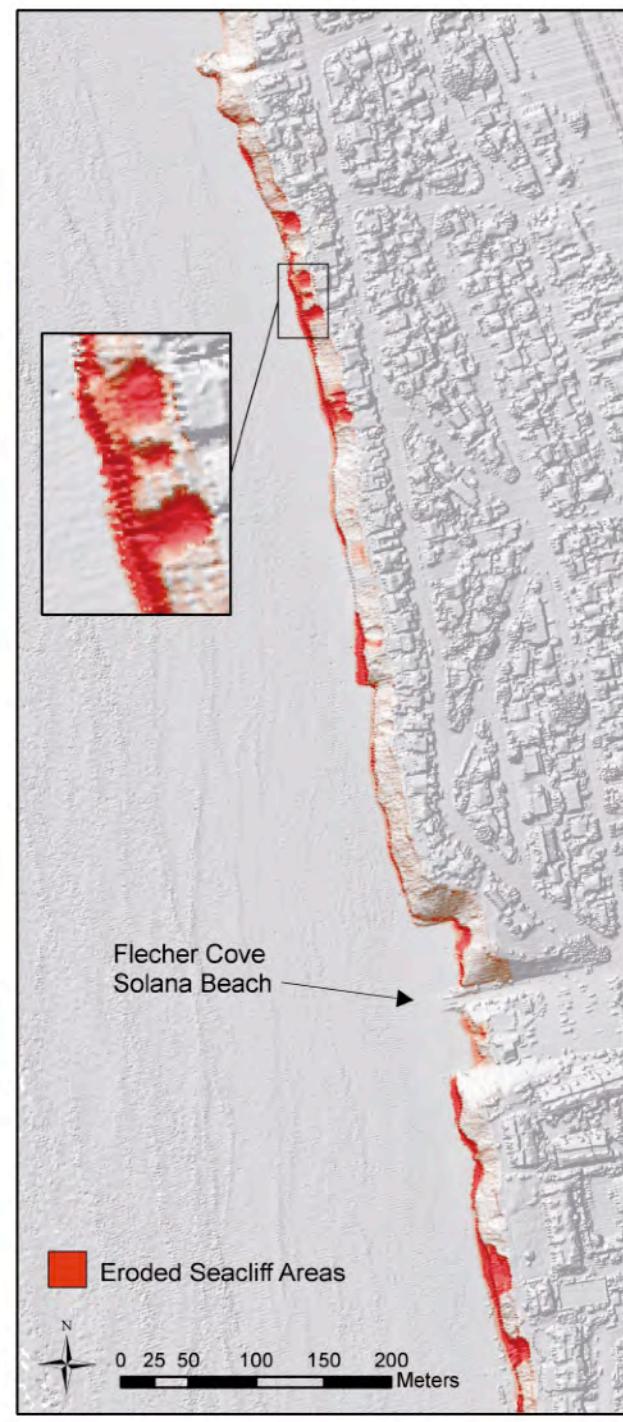
1. Abrasion of a Basal Notch
2. Thresholded Failure
3. Communition Lag - Protective Feedback



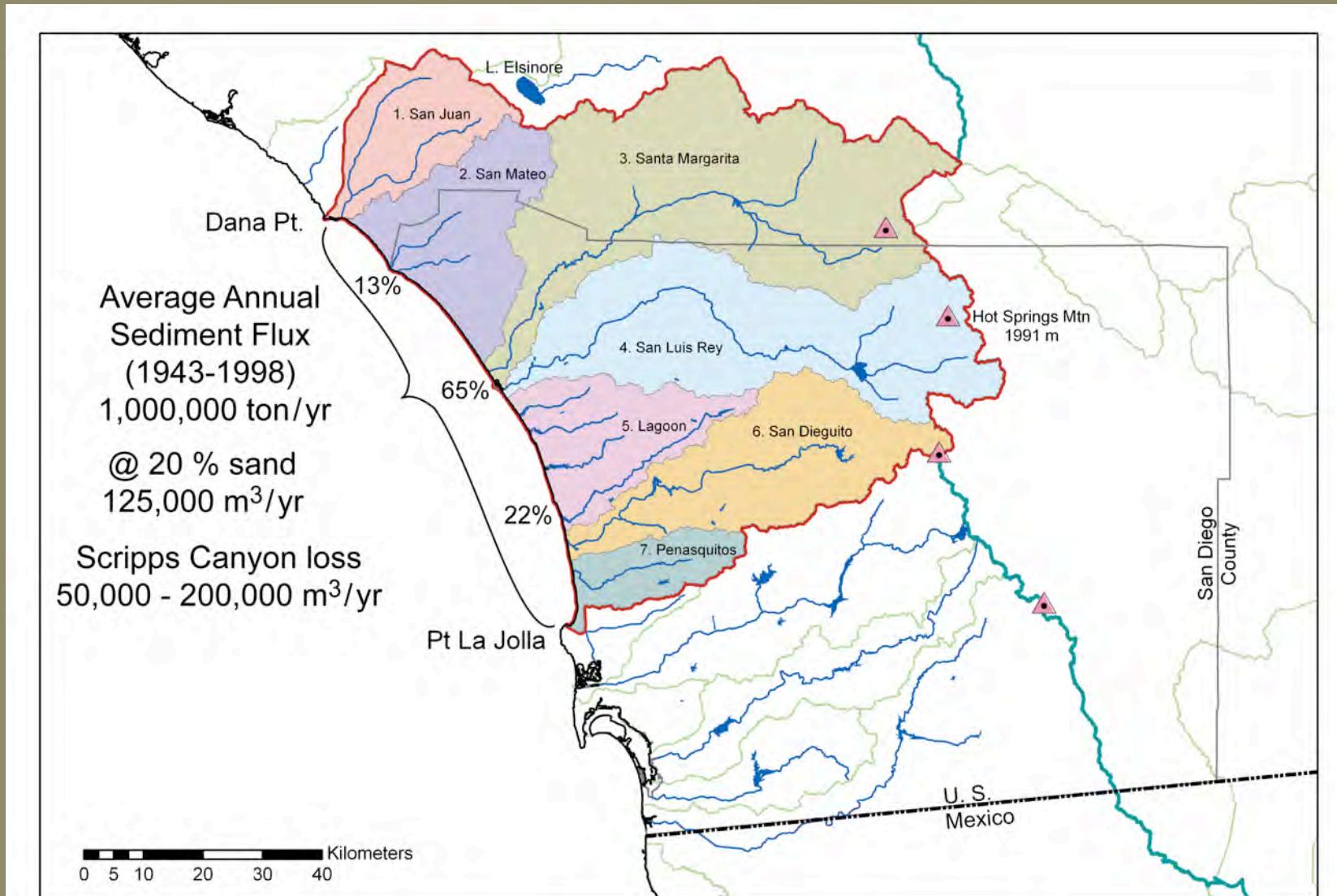
Retreat History

# Terrestrial Zone Module

Data from Young and Ashford, 2006



# Terrestrial Zone Module



Seven drainage basins of the Oceanside Littoral Cell.

03.K1-1a

# Establishing a Proxy Wave Climate



Analyze 50-year numerical hindcast record of deep-water wave conditions (Graham & Diaz, 2001)

Apply trends from hindcast to longer climate record (Moy et al., 2002)

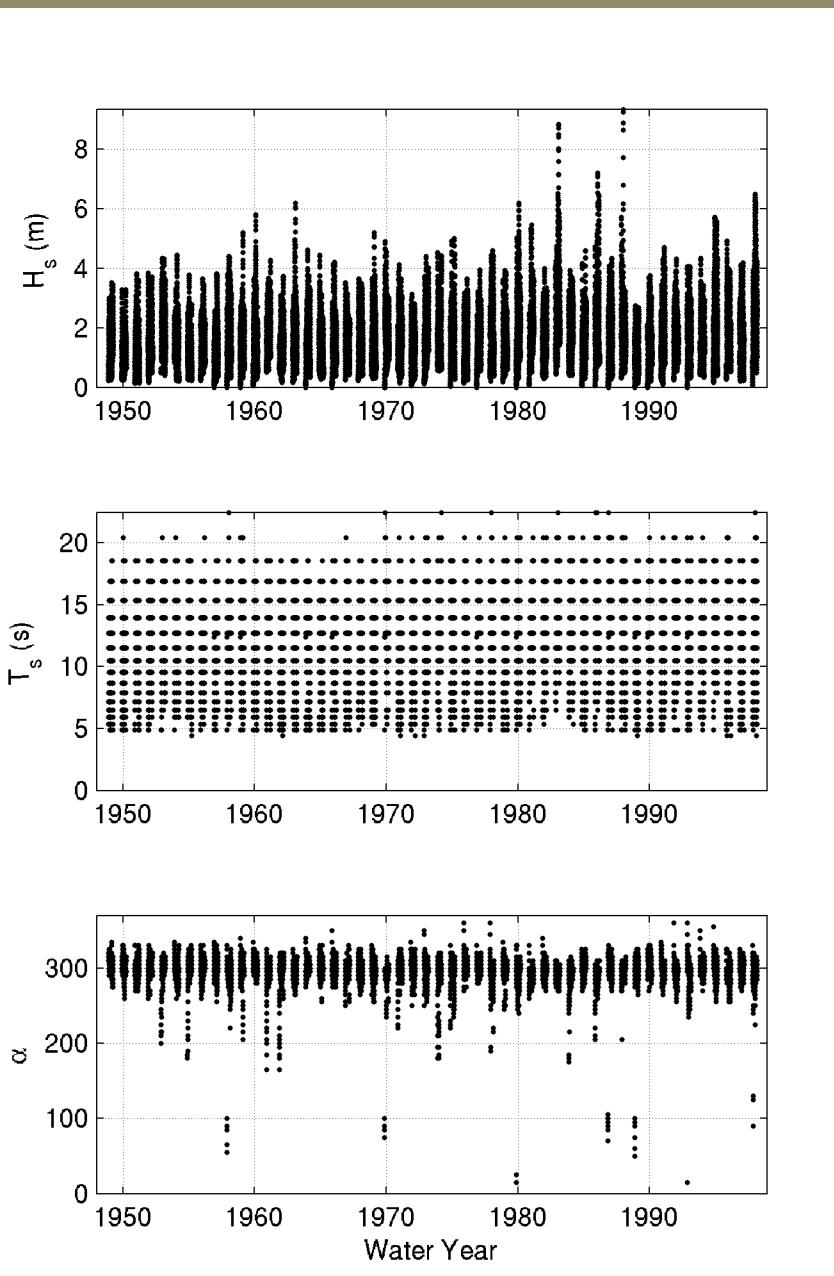
Couple proxy wave climate with past (or future) sea level record

# Wave Hindcast Data

50-year numerical hindcast record  
of deep-water wave conditions  
(Graham & Diaz, 2001)

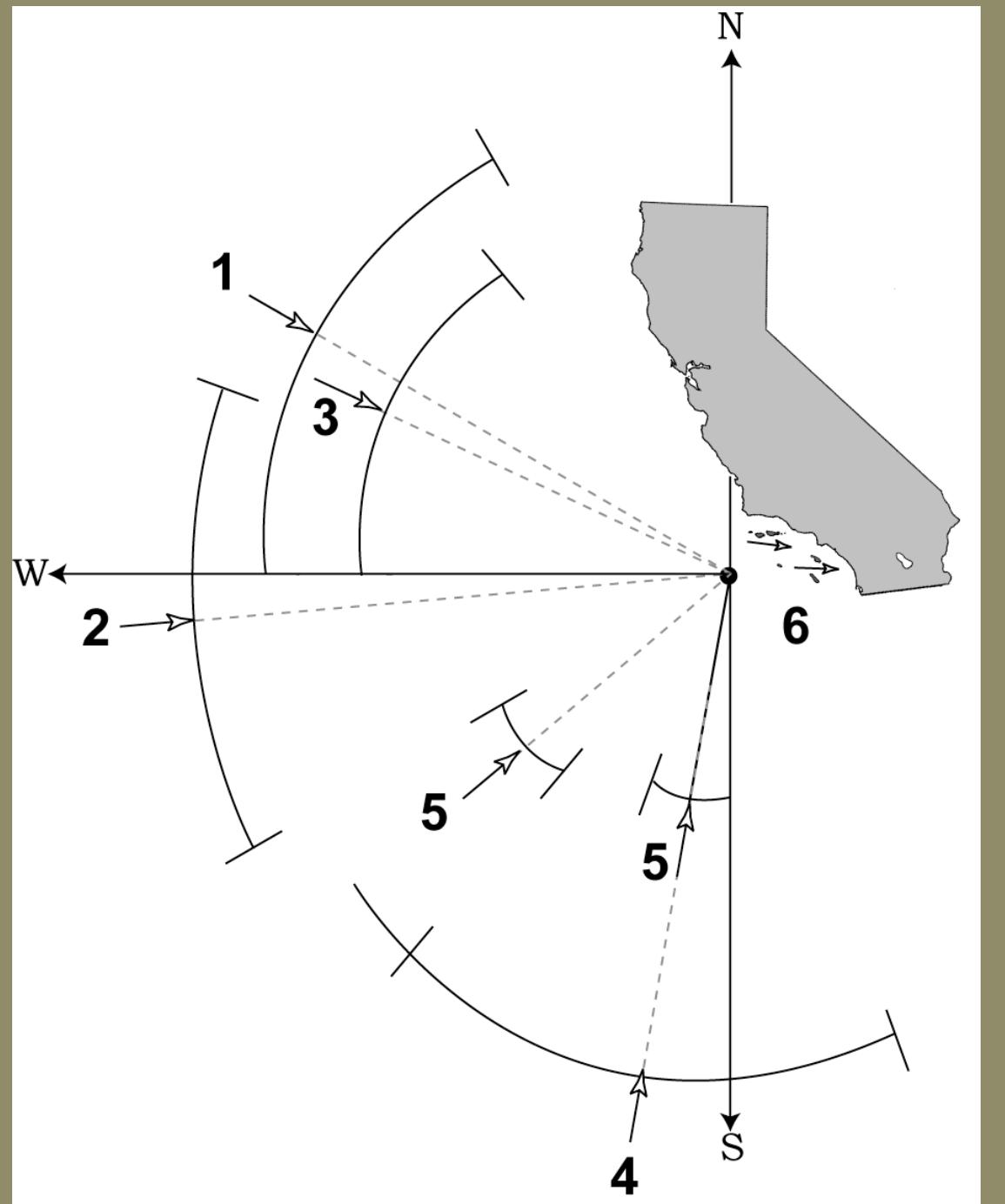
Winter wave conditions (DJFM -  
1948-98)

Previous analysis recognized trend  
of increasing wave heights

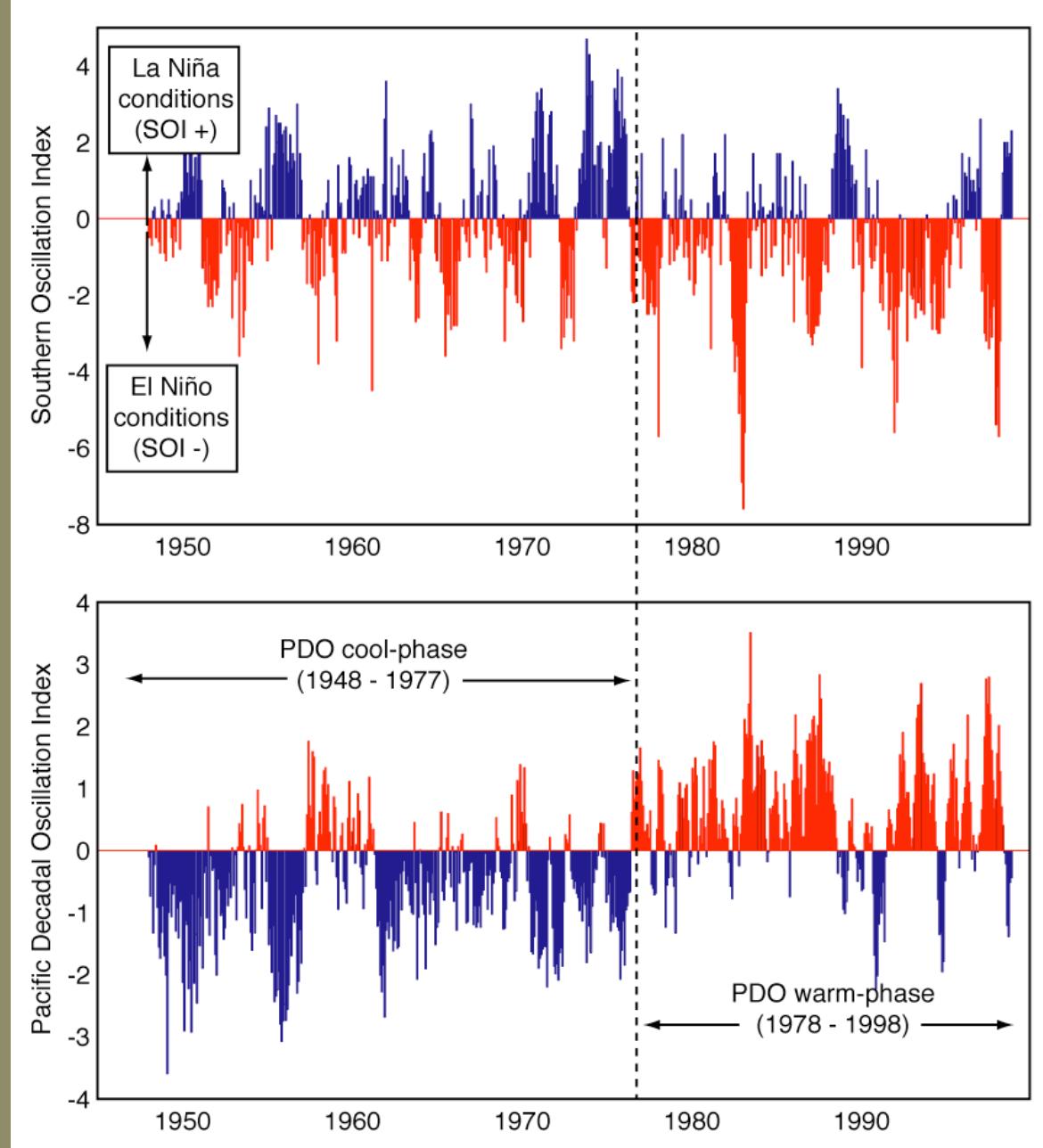


# Wave Sources

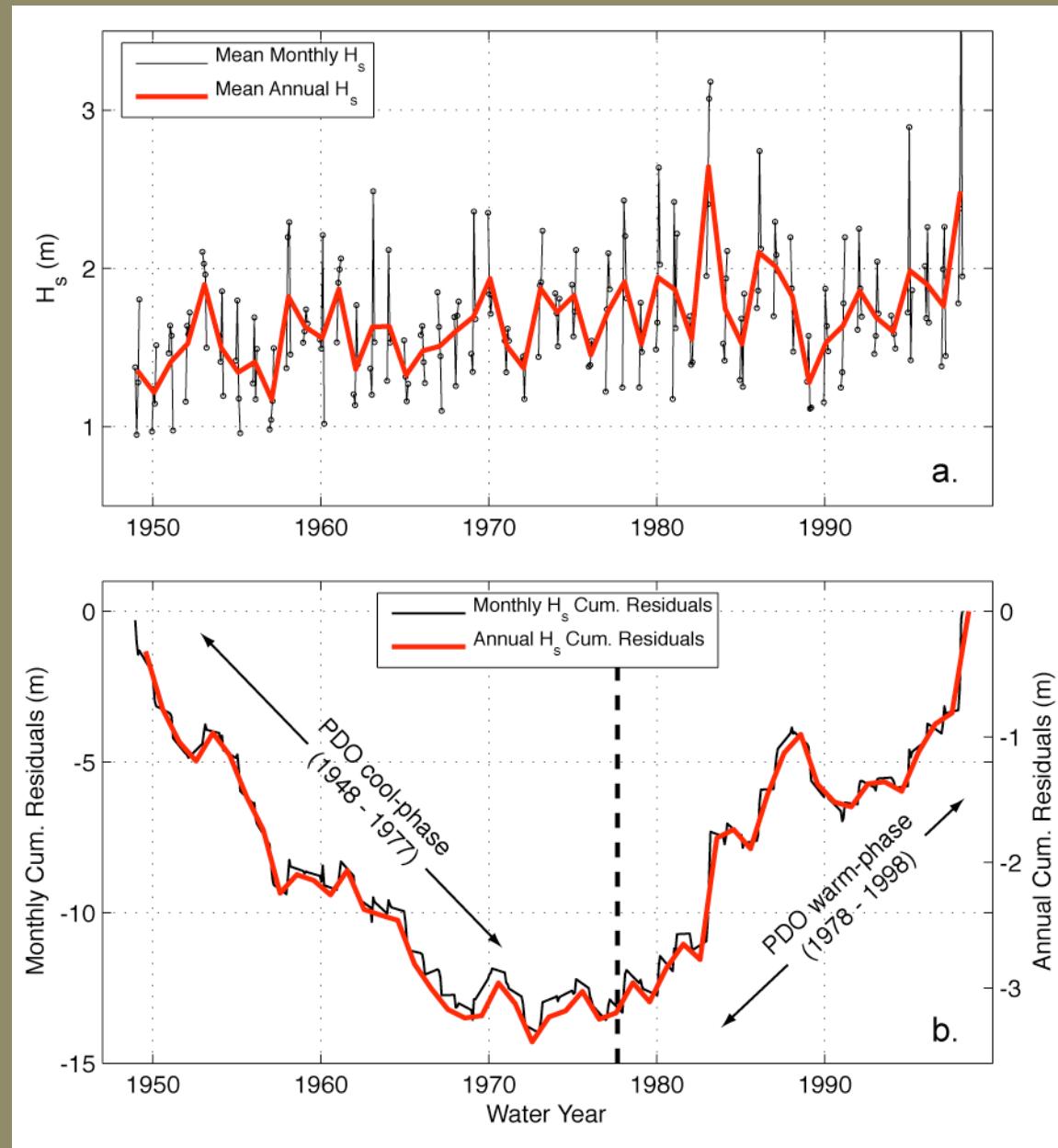
1. Aleutian Low
2. Pineapple Express
3. N. Pacific High
4. So. Hemisphere Swell
5. Tropical Storms
6. Sea Breeze



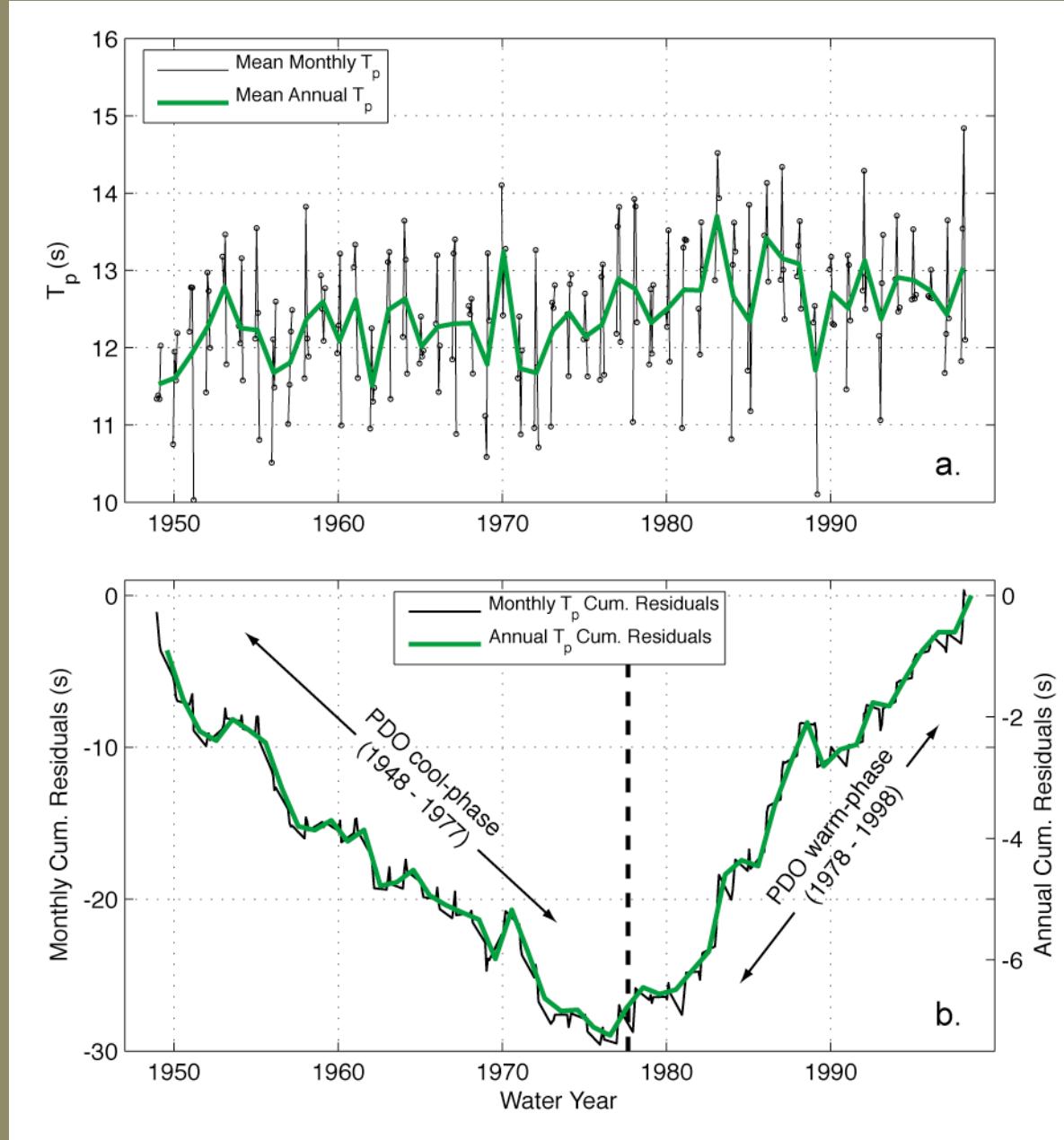
# ENSO and the PDO



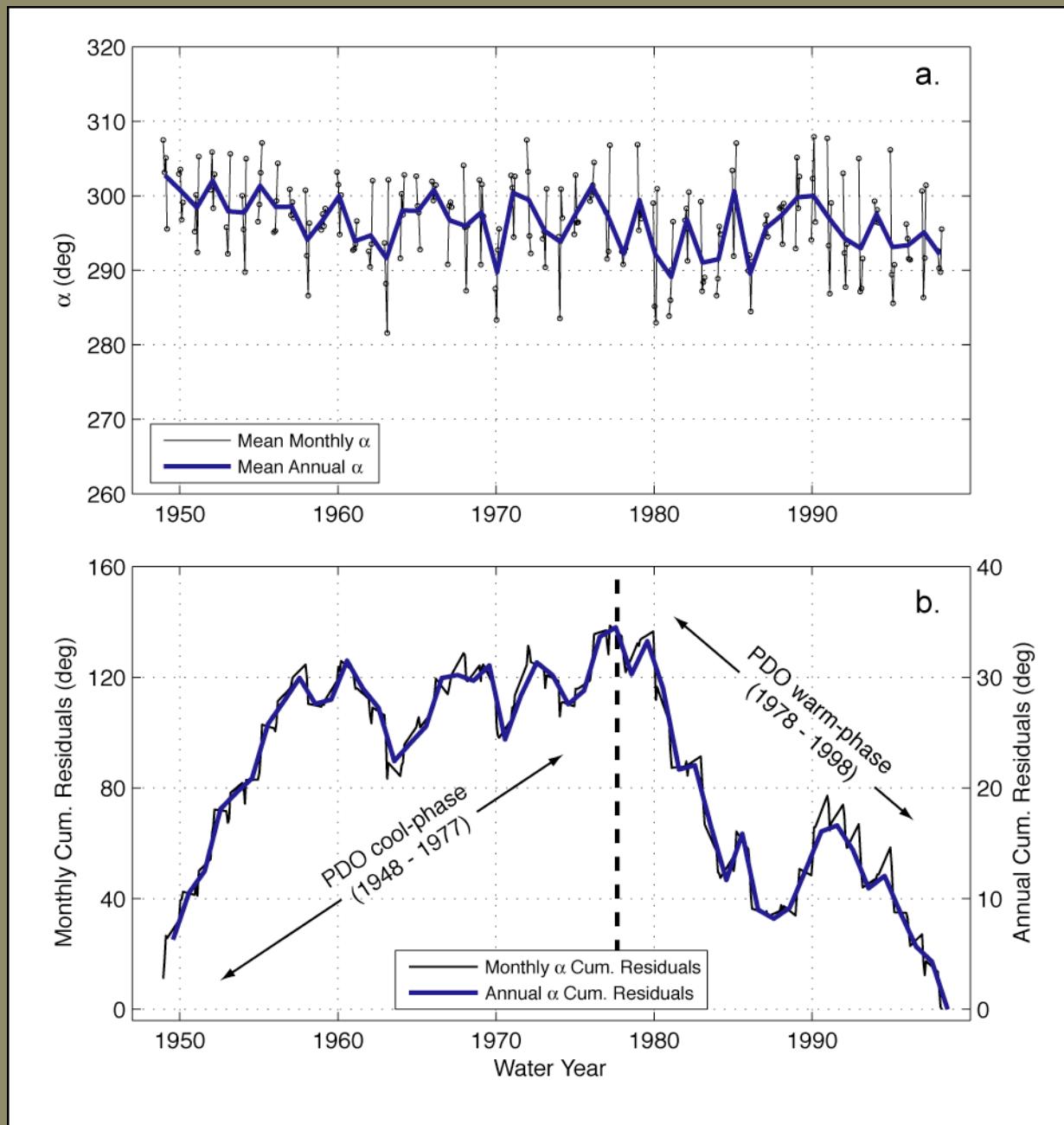
# Wave Heights



# Wave Periods



# Wave Directions



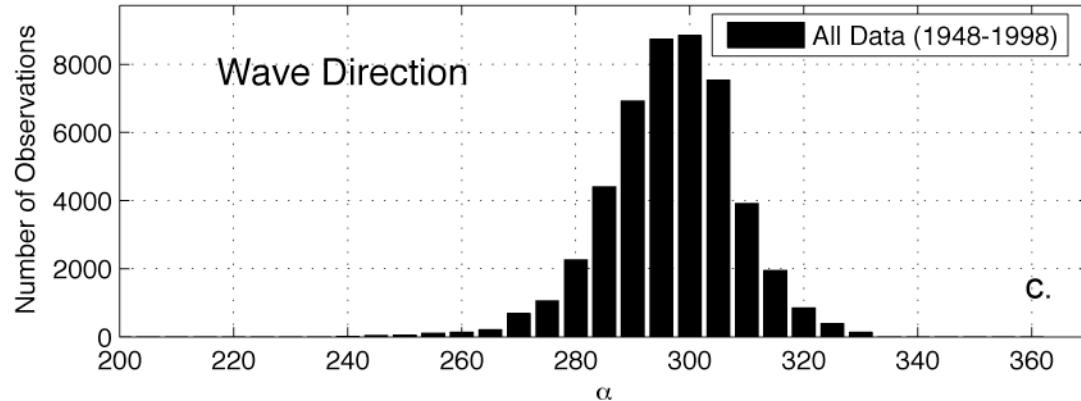
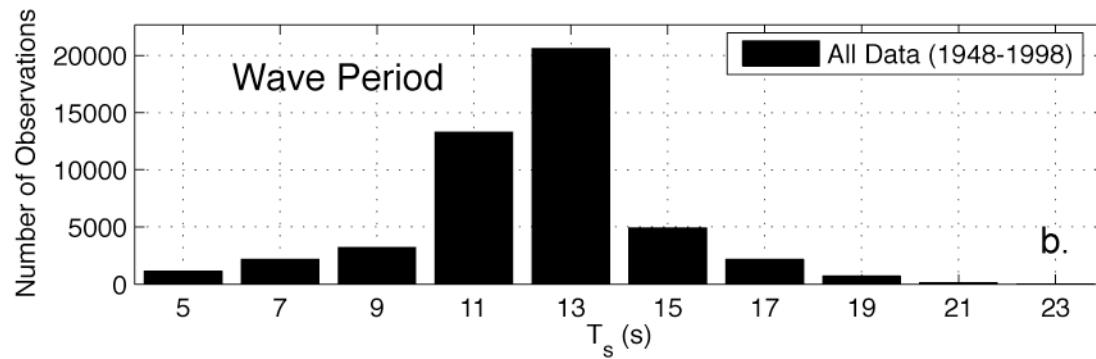
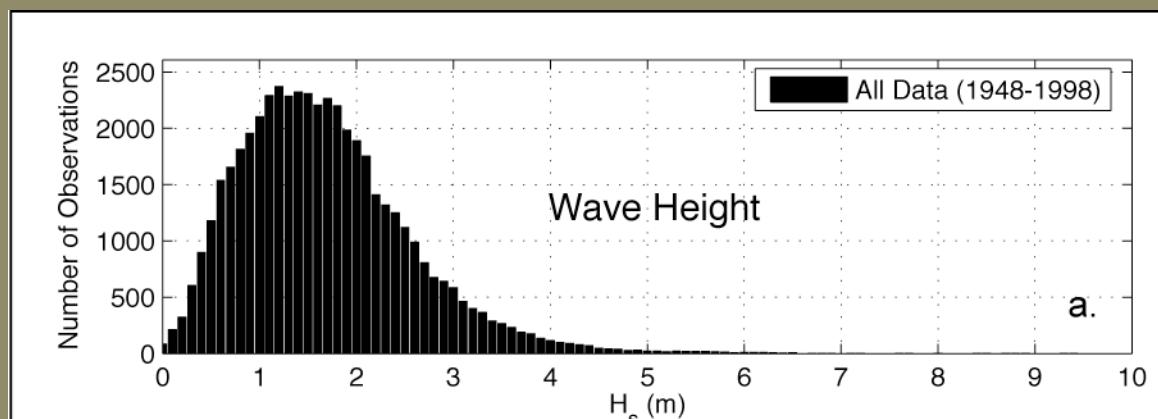
# Data Population Distributions

$$H_s = 1.68 \pm 0.89 \text{ m}$$

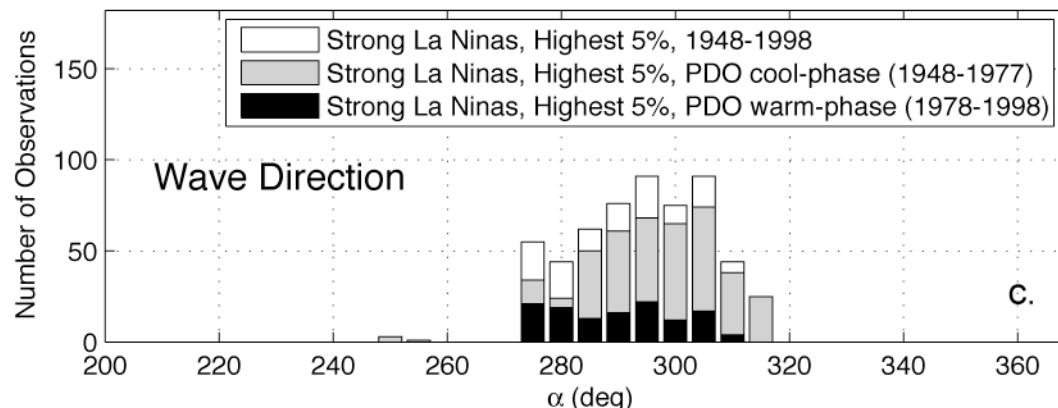
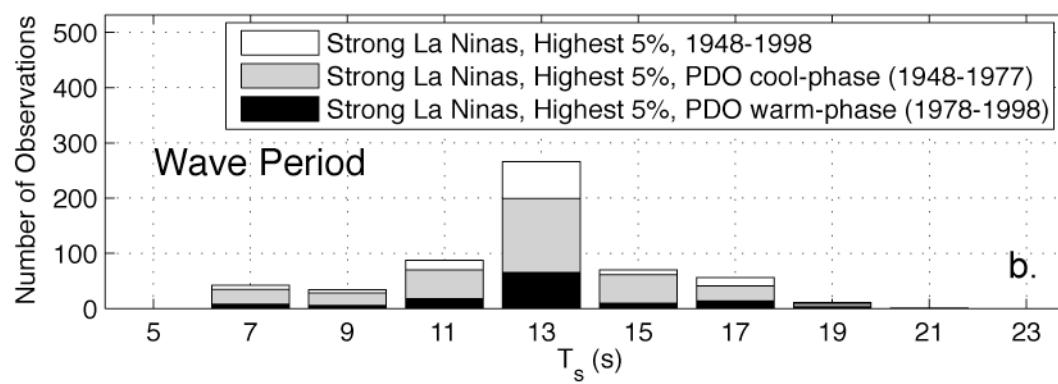
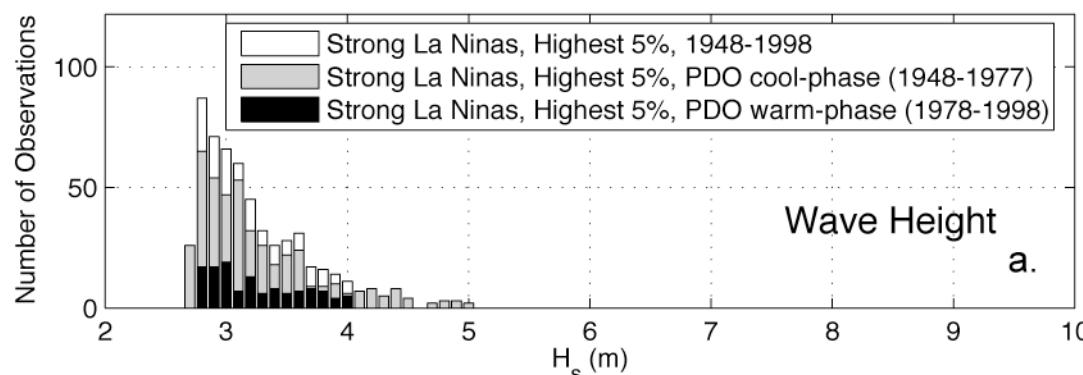
$$T_p = 12.4 \pm 2.6 \text{ s}$$

$$\alpha = 296 \pm 13^\circ$$

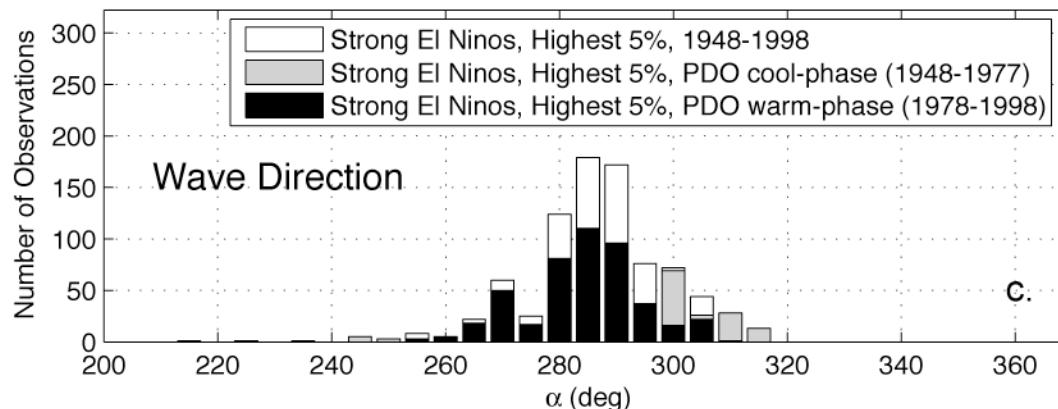
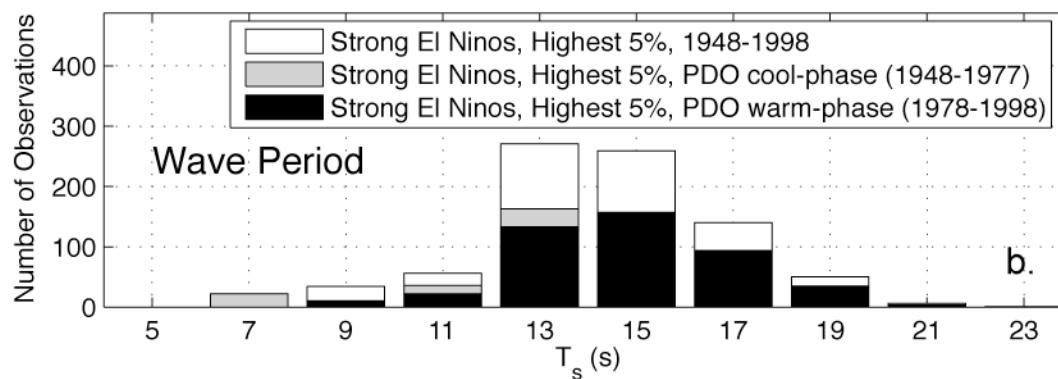
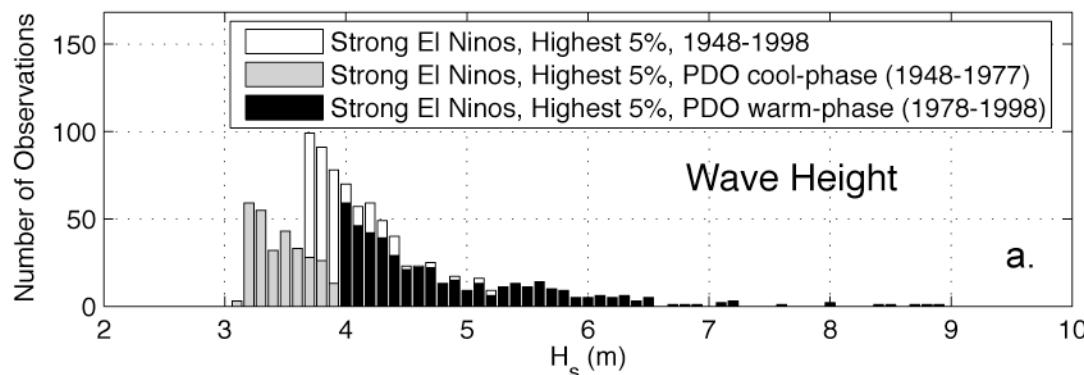
$n = 48,446$  observations



# La Niñas



# El Niños



$$H_{s,PDO\ cool} = 3.6 \text{ m}$$

$$H_{s,PDO\ warm} = 4.8 \text{ m}$$

$$T_{p,PDO\ cool} = 13.8 \text{ s}$$

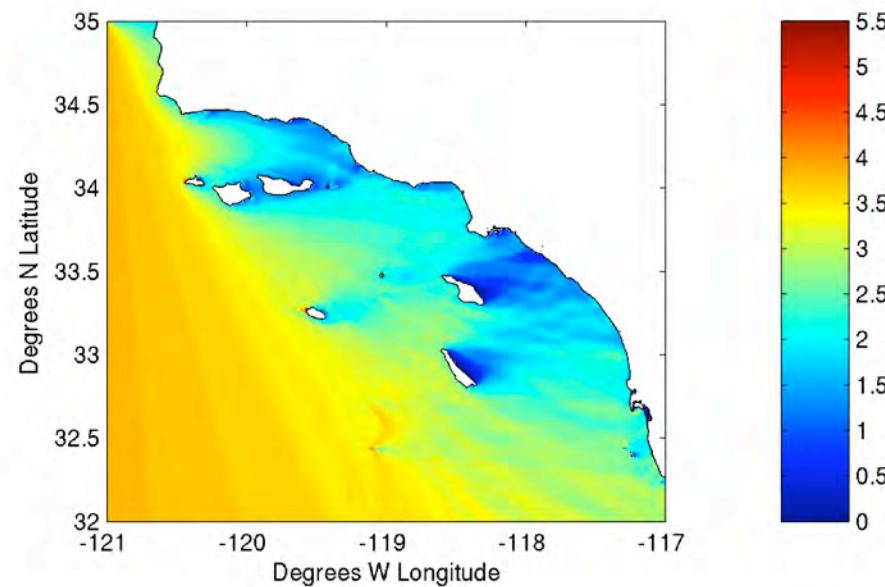
$$T_{p,PDO\ warm} = 15.1 \text{ s}$$

$$\alpha_{,PDO\ cool} = 292^\circ$$

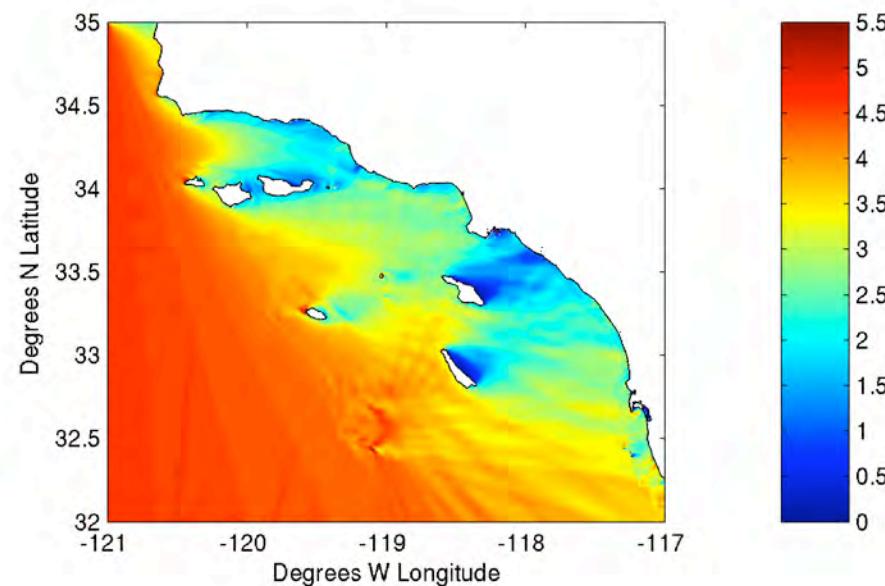
$$\alpha_{,PDO\ warm} = 284^\circ$$

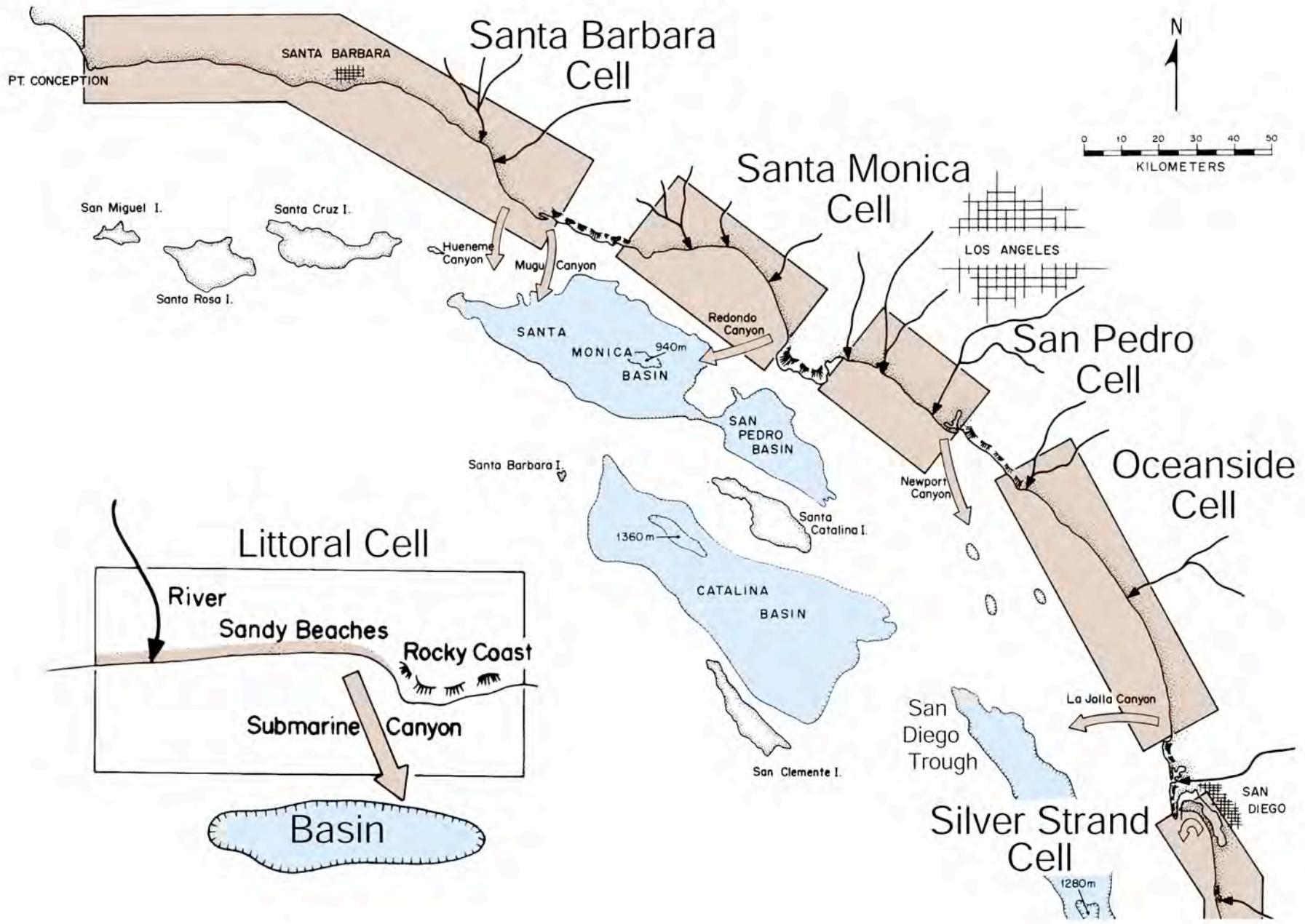
# Model Results - So. California Bight

El Niño, PDO cool-phase



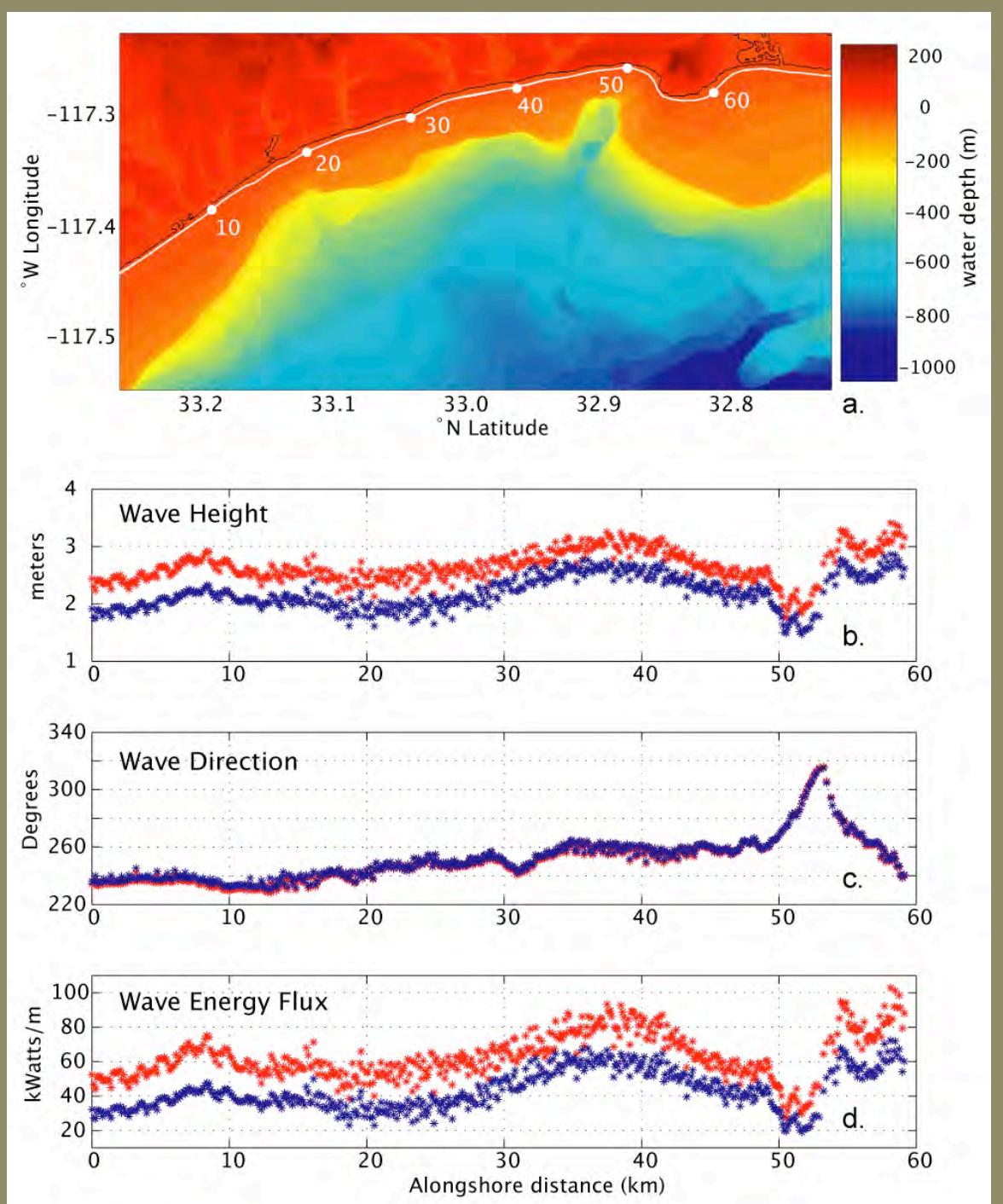
El Niño, PDO warm-phase





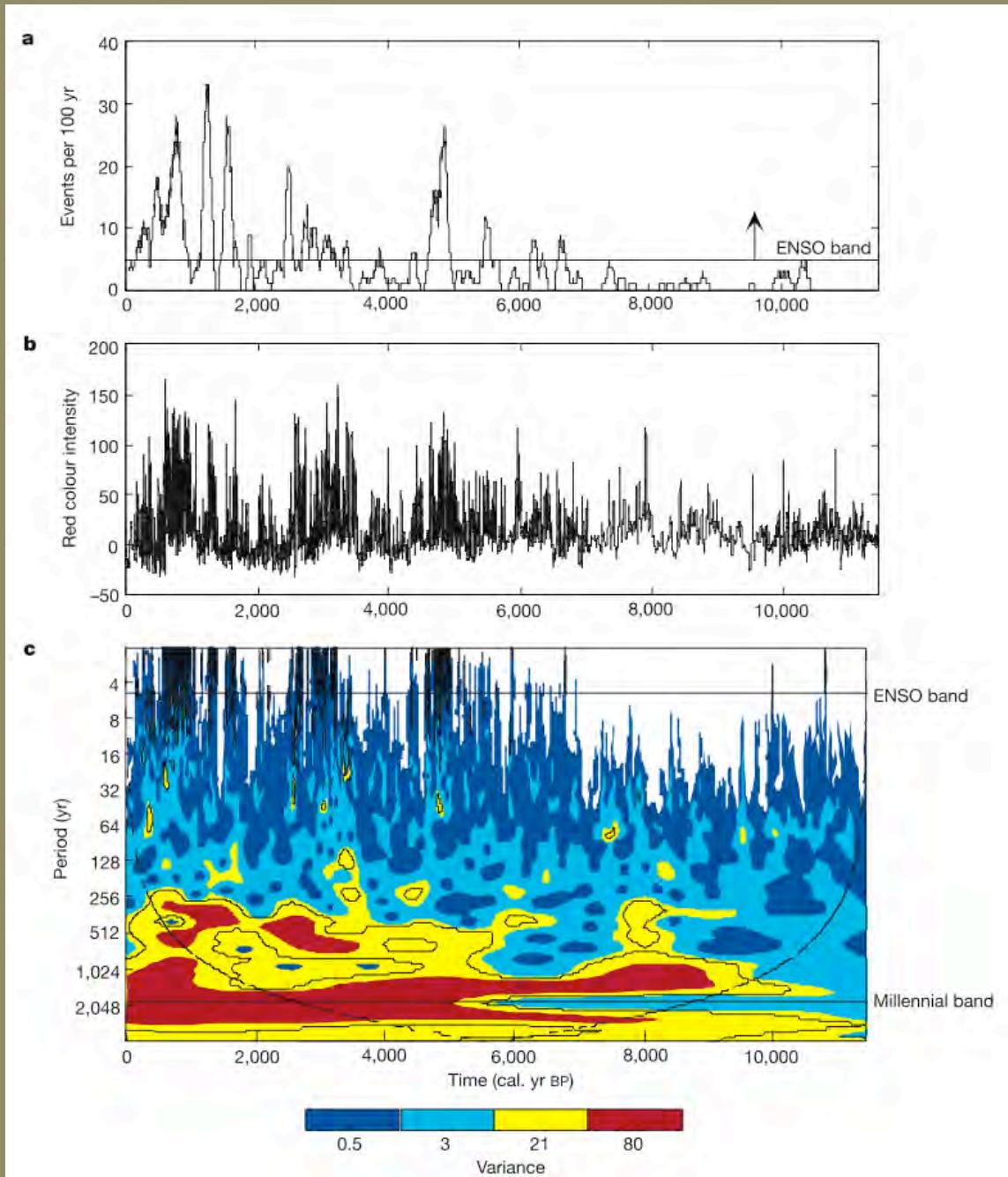
Littoral cells of the Southern California Bight [after Inman and Frautschi, 1965].

# Models - Oceanside Littoral Cell



# Holocene ENSO record

Analysis of Moy et al., 2002



# Summary

3 modules of Geomorphic Coastal Evolution Model

Results from first step, defining proxy wave climate

Next step, use wave climate with sea level projections to identify hotspots of coastal erosion